# Do climate variations explain international migration?

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# Motivation

- Nexus climate change and migration addressed since the early 1990s by political scientists, environmentalists and demographers
- Substantial media coverage but limited academic research
- Mainly case studies for specific regions/countries and time episodes (World Bank, 2010)
- The number of empirical studies quantifying this impact is limited

# Motivation (cont)

- Natural disasters and extreme events as drivers: Marchiori, Maystadt and Schumacher, 2011; Lilleor and Van den Broeck, 2011;Beine and Parsons, 2015; Groeschl and Steinwachs,2016
- I focus on **permanent migration due to gradual climate change** (Backhaus et al, 2015; Cai et al, 2016; Cattaneo and Peri, 2016)
- Investigate further the differential effect found by Cattaneo and Peri (2016) for different country groups →using Backhaus et al dataset
- Target variables: Average temperature and precipitation

# Related Literature

*Early multi-country studies on the link migration-climate change*:

- *Barrios (2006) on internal migration:* rainfall shocks induce internal migration in SSA but not in other developing countries,
- *Marchiori et al. (2011) on international migration:* 43 SSA countries, climate variations increase the incentives to migrate internationally via changes in the wage ratio, but urbanisation mitigates the effect on international migration

*GDP growth and climate change*:

- Dell et al. (2008) use **within-country year-to-year fluctuations in the climatic variables** in order to partially overcome omitted variable bias due to other unobservable country-specific determinants of GDP

# Related Literature (cont)

- Effect of average temperature and rainfall on emigration→
  - Backhaus et al., 2015: GM, *yearly* inflows
  - Cai et al., 2016: GM, *yearly e*migration rate
  - Cattaneo and Peri, 2016 : Country-decade emig. Rates
- Deviations of rainfall and temperature from "normal" levels, natural disasters →
  - Beine and Parsons, 2015: GM, decade, inflows
  - Coniglio and Pesce, 2016 : GM, *yearly*

# Related Literature (cont)

**Backhaus et al., 2015:** Average temperature positively correlated with bilateral migration, mainly *for agricultural-depending countries*

**Cai et al.**: Each 1 °C increase in temperature implies a 5% increase in out migration from the top 25% *agricultural countries* (significant at the 1% level)

**Cattaneo and Peri, 2016**: Climatic warming associated with significantly higher emigration rates in *middle-income countries and significantly lower rates in poor countries*

**Beine and Parsons, 2015**:No evidence of direct impacts of climate anomalies on international migration but only an indirect effect through wage differentials

**Coniglio and Pesce, 2016**: An increase in  rainfall variability (also in anomalies) is associated with an increase in average bilateral migration

| Study | Countries | Period | Method | Migration type and measure | Climate variables | Main Finding |
|---|---|---|---|---|---|---|
| **Barrios et al (2006)** | 78 countries | 1960-1990 | Cross-country panel data with country and time FE | Internal, Urbanization as a proxy | Rainfall level normalized by the mean | Rainfall shocks induce migration in SSA only |
| **Marchiori et al (2012)** | 43 SSA countries | 1960-2000, | Cross-country panel data with country and time-region FE | International, Net migration rate | Precipitation and temperature anomalies | Positive (negative) effect of rainfall (temperature) anomalies via wage ratio |
| **Backhaus et al (2015)** | 142 sending countries to 19 OECD destinations | 1995-2006, yearly basis | Gravity model with country-pair and time FE, estimation in first differences | International, Bilateral migration inflows | Population-weighted Average temperature and precipitation | Average temperature is positively correlated with bilateral migration, mainly for agricultural-depending countries |
| **Beine and Parsons (2015)** | 226 origin and destination countries | 1960-2000, ten year intervals (5 waves) | Gravity model with origin and destination-time FE (PPML ) | International, bilateral migration rate | natural disasters and average deviations of decadal average temperature and rainfall and anomalies | no evidence of direct impacts of climate anomalies on international migration but only an indirect effect through wage differentials |
| **Coniglio and Pesce (2015)** | 128 origin and 29 OECD destinations (Listed in online Appendix) | 1990-2001, yearly basis | Gravity model with origin and destination-time FE (PPML) | International, Bilateral migration inflows | Rainfall and temperature surplus and deficit, index of excess rainfall variability | an increase in rainfall variability (also in anomalies) is associated with an increase in average bilateral migration |
| **Cai et al (2016)** | 163 sending countries to 42 destinations | 1980-2010, yearly basis | Gravity model with country-pair and origin and destination linear trends | International, bilateral migration rate | Population-weighted Average temperature and precipitation | Each1 °C increase in temperature implies a 5% increase in out migration from the top 25% agricultural countries (significant athte 1% level) |
| **Cattaneo and Peri (2016)** | 115 sending and receiving countries (30 poor and 85 middle-income) (Data in online Appendix) | 1960-2000, ten year intervals | Cross-country panel data with country and time-region FE | International, Net emigration flows (diff between stocks in two consecutive census) from Ozden et al. (2011) | Population-weighted Average temperature and precipitation from Dell et al. (2012) | climatic warming associated with significantly higher emigration rates in middle-income countries and significantly lower rates in poor countries |

# Modelling framework

- The neoclassical approach to migration: a rational individual that takes his decision to migrate on purely economic grounds and acts independently of other social entities: Borjas (2005)

- In a simple 2-period model (Cattaneo and Peri, 2016), the decision to migrate for individual *i implies a comparison* between the net income when migrating and staying. Thus,

*(wage destination-cost of migrate)>wage origin* → *Mig.*

# Predictions

- P1: An increase in average temperature →Increases the emigration rate in middle-income countries
- P2: An increase in average temperature→ Decreases the emigration rate in poor countries, because their wages are not high enough to cover the monetary cost of migration
- Considering a sending country (s) that is middle or low income (P), the derived empirical model is,

$$\ln\left(\frac{Mig_s}{Pop_s}\right) = \alpha + \gamma \ln T_s + \gamma_P \ln T_s D(s \in P) + \beta C_s \qquad (1)$$

# Empirical strategy

- We use the same approach as in Cattaneo and Peri (2016) and estimate equation (1) using Backhaus et al. dataset using only climatic variables and a battery of fixed effects:
- Adding year-quartile income distribution interaction dummy variables
- Time-region dummy variables

# Empirical strategy (cont)

- We also use the grouped fixed-effects (GFE) approach recently proposed by Bonhomme and Manresa (2015)
- Introduces time-varying grouped patters of heterogeneity in linear panel data models that are common within groups of countries.
- Both the group-specific time patterns and the group membership are estimated from the data.

$$\ln Mig_{it} = x_{it}^{'}\beta + \gamma_{g_i t} + u_{it} \qquad (2)$$

# Empirical strategy

- The GFE in model (2) is the outcome of the minimization of the following expression:

$$(\hat{\beta},\hat{\gamma},\hat{\alpha}) = \underset{(\beta,\gamma,\alpha)\in\Theta x A^{GT} x \Gamma_G}{\operatorname{argmin}} \sum_{i}^{N}\sum_{t}^{T}\left(\ln Mig_{it} - x'_{it}\beta - \gamma_{g_i t}\right)^2 \qquad (3)$$

where the minimum is taken over all possible groupings $\alpha=\{g_1,\ldots,g_n\}$ of the N units into groups G, parameters β and group-specific time effects γ

# Data and Variables

- Dataset 1: Backhaus et al (2015):
  - Migration flows and stocks in destination countries are mainly from the OECD's International Migration Database (IMD) from 1995 to 2008
  - Average temperature and average precipitation both are from Dell et al (2008)→Geospatial software used to aggregate both variables to the country-year level
  - Sample: 1995-2006, 19 destinations and 127(161) origins
- Dataset 2: Cattaneo and Peri (2016)
  - Sample: Decade data 1960-2000, 115 non-OECD countries, emig. Rates (and urbanization)

# Data and Variables

**Migration (Backhaus et al):**

- In total, about 38.5 m. people emigrated from their home countries and moved to the destination countries during the observation period: 1995-2008
  - 44.94% originate from lower-middle-income countries
  - 38.16% from upper-middle-income
- The high- and low-income countries (10.7 % and 6.11%) exhibit the smallest emigration flows both in absolute and relative terms.
- The second case might be an indication of poverty constraint on migration

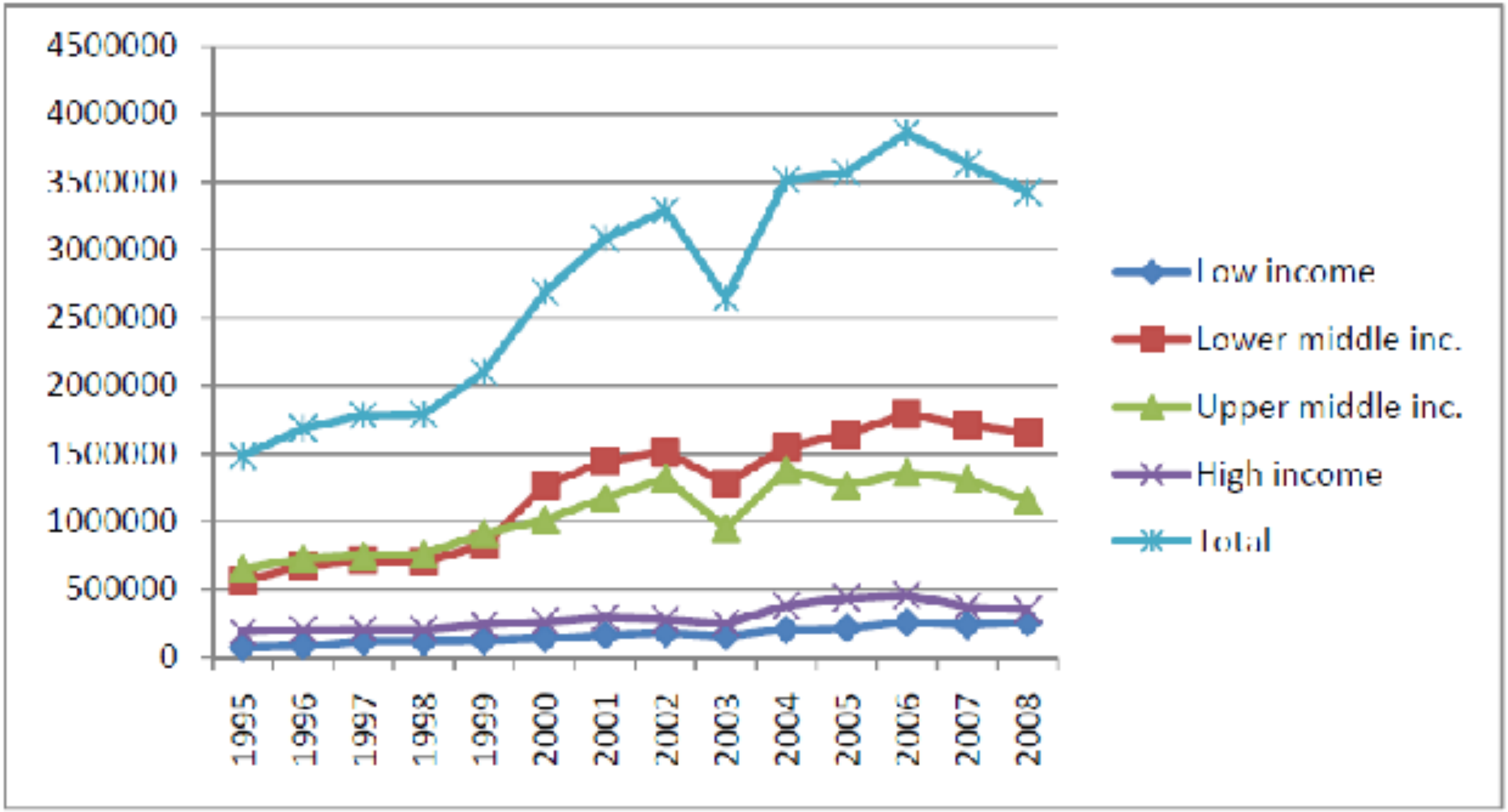
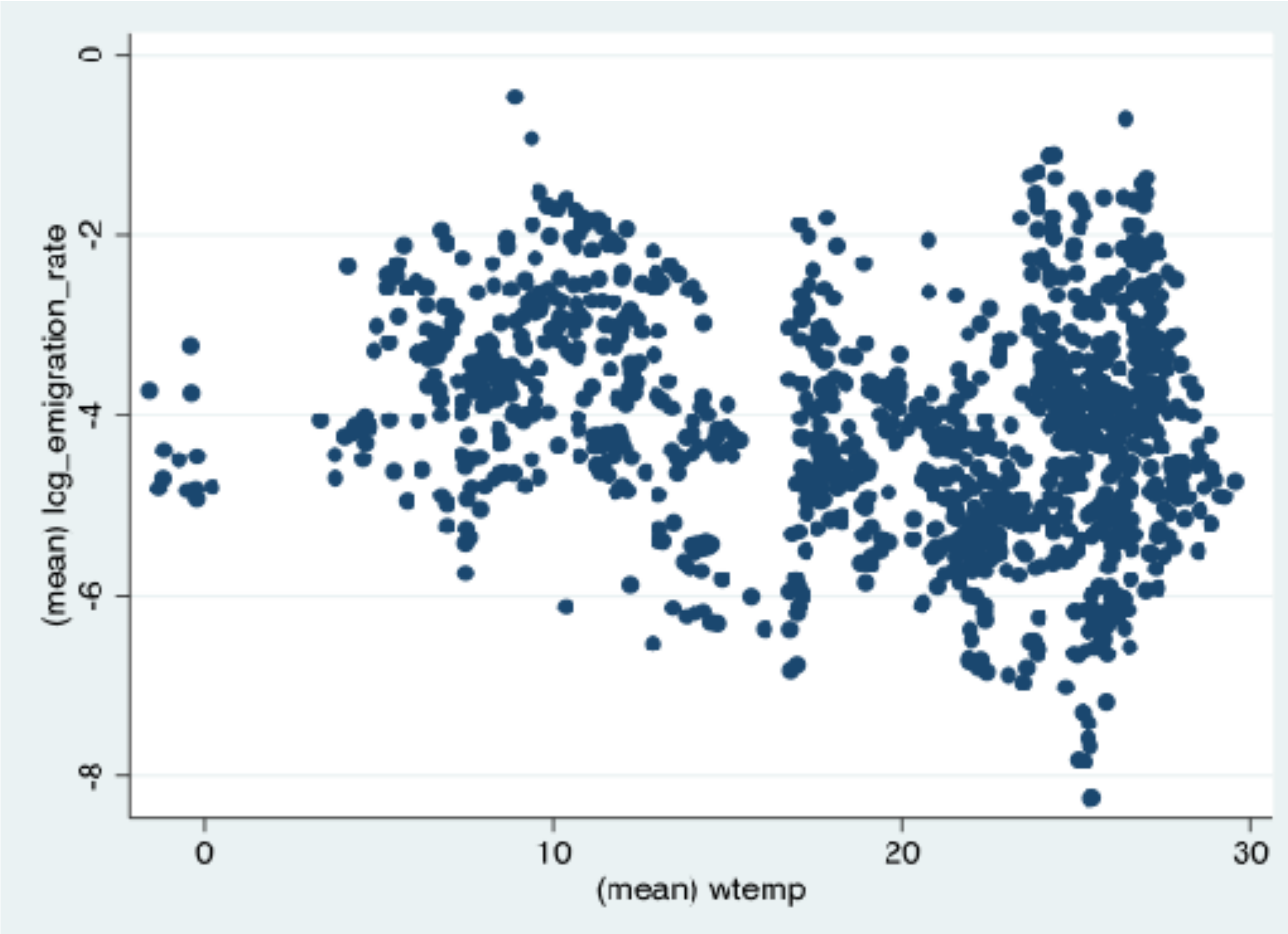
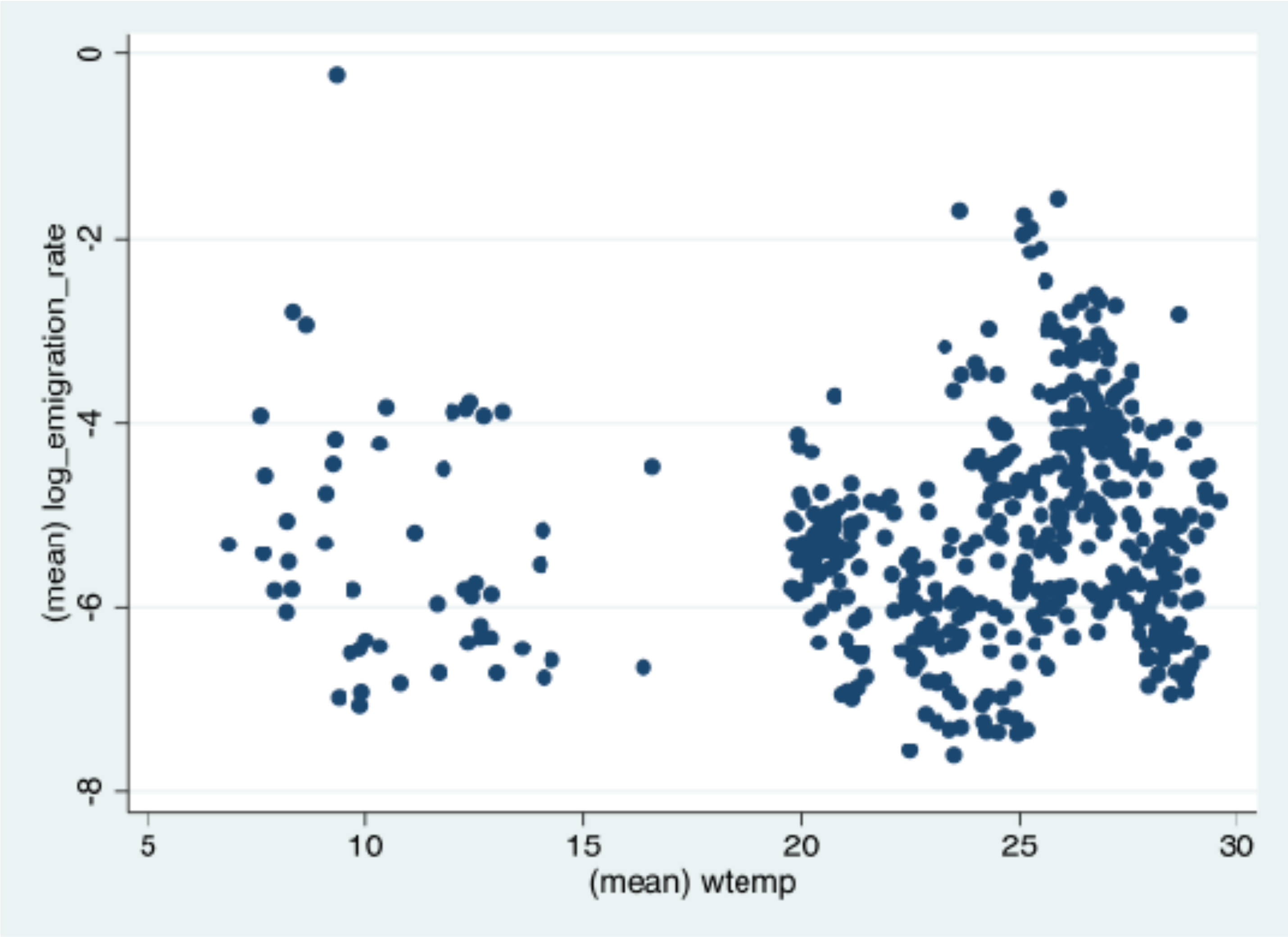



**Figure 1: Emigration by source country income classification over time**

# Scatter plot MIC



# Scatter plot LIC



# Summary statistics (dataset 1)

| Variable | Obs | Mean | Std. Dev. |
|---|---|---|---|
| emigration rate | 1,704 | 0.137 | 0.247 |
| log_emigrate | 1,693 | -4.441 | 1.301 |
| wtemp | 1,704 | 20.643 | 6.888 |
| wpre | 1,704 | 10.910 | 7.415 |
| gdpcap_ 1000 | 1,605 | 5.580 | 7.922 |
| log_pop | 1,704 | 15.814 | 1.689 |
| demographic presure | 1,704 | 59.478 | 6.487 |
| stability | 1,134 | -0.369 | 0.925 |
| sfi | 1,613 | 11.777 | 5.942 |
| unemployment | 778 | 10.023 | 6.454 |
| max_temp | 1,704 | 21.294 | 6.742 |
| min_temp | 1,704 | 19.940 | 7.088 |
| Share agricultural land | 1,704 | 41.107 | 22.445 |
| steady_wtemp_change | 1,278 | 0.128 | 0.335 |
| steady_wpre_change | 1,278 | 0.095 | 0.293 |
| | | | |
| inflows | 1,704 | 1370.405 | 2640.830 |
| log_inflows | 1,693 | 4.474 | 1.614 |

Mean Emigration rate

Poor=0.04

MIC=0.17

# Summary statistics (dataset 2)

able 1
ummary statistics.

| Countries included in the sample | Non-OECD sample middle-income countries | | | Non-OECD sample poor countries | | |
|---|---|---|---|---|---|---|
| Variable | Obs | Mean | Std. dev. | Obs | Mean | Std. dev. |
| Emigration rate (emigration flows/population) | 338 | 0.042 | 0.084 | 120 | 0.018 | 0.020 |
| Temperature, °C (pop weight) | 338 | 22.118 | 4.925 | 120 | 23.499 | 4.172 |
| Precipitation, 100s mm/year (pop weight) | 338 | 13.406 | 8.818 | 120 | 11.407 | 5.157 |
| Temperature, °C (area weight) | 330 | 22.251 | 5.064 | 120 | 23.894 | 3.968 |
| Precipitation, 100s mm/year (area weight) | 330 | 13.255 | 9.175 | 120 | 10.894 | 5.742 |
| Share of urban population | 420 | 0.422 | 0.222 | 145 | 0.194 | 0.112 |
| Emigration rate (to non-OECD destinations) | 338 | 0.014 | 0.034 | 120 | 0.014 | 0.018 |
| Emigration rate (to OECD destinations) | 338 | 0.028 | 0.073 | 120 | 0.004 | 0.007 |
| Emigration rate ( to close destinations) | 289 | 0.009 | 0.037 | 104 | 0.010 | 0.018 |
| Emigration rate (to distant destinations) | 338 | 0.033 | 0.065 | 120 | 0.009 | 0.011 |
| Agriculture, value added (% of GDP) (WDI source) | 242 | 16.298 | 11.147 | 83 | 34.787 | 11.992 |

lote: The first three columns of the table show the summary statistics including as country of origin of immigrants non-OECD countries, excluding those in the bo
f the GDP per capita distribution. The remaining three columns show the summary statistics for the sample of non-OECD countries in the bottom quartile of the p
istribution. The sample is supposed to include countries of the world that are "Poor" or "Middle-Income".

Source: Cattaneo and Peri (2016)

## Main Results

Replication of Cattaneo and Peri,C&P (2016) with Backhaus et al (2015) data

- Table 2
  - Similar results with same 115 countries

| Dep. Variable: | (1) | (2) | (3) | |
|---|---|---|---|---|
| **ln_emig rate** | **FE** | **FE** | **FE** | **C&P (2016)** |
| **Exp. Variables:** | **no_logs** | **logs** | **logs** | **logs** |
| wtemp_initxtilegdp1 | -0.162 | **-4.527**** | **-4.842**** | **-16.476***** |
| | [0.105] | [2.154] | [2.430] | (6.250) |
| wtemp_initxtilegdp2 | -0.0247 | 0.828 | 1.564 | 7.474 |
| | [0.0924] | [1.368] | [1.198] | (6.824) |
| wtemp_initxtilegdp3 | **0.124*** | **1.947***** | **2.086***** | **8.614*** |
| | [0.0700] | [0.734] | [0.751] | (5.143) |
| wtemp_initxtilegdp4 | 0.0633 | **1.595***** | **1.980***** | **2.840**** |
| | [0.0639] | [0.435] | [0.527] | (1.391) |
| wpre_initxtilegdp1 | -0.0157 | **-0.273*** | **-0.335**** | -1.643 |
| | [0.0127] | [0.156] | [0.162] | (1.902) |
| wpre_initxtilegdp2 | 0.0204 | **0.256*** | **0.343**** | **-1.684**** |
| | [0.0153] | [0.142] | [0.142] | (0.658) |
| wpre_initxtilegdp3 | 0.0163 | 0.0994 | 0.0474 | 0.097 |
| | [0.0163] | [0.137] | [0.137] | (0.404) |
| wpre_initxtilegdp4 | 0.00848 | 0.032 | 0.0182 | 0.434 |
| | [0.0124] | [0.175] | [0.207] | (0.642) |
| Country FE | Yes | Yes | Yes | Yes |
| Year (decade)-quartile FE | Yes | Yes | Yes | Yes |
| Year3 (decade)-region FE | Yes | Yes | Yes | Yes |
| Observations | 1,522 | 1,511 | 1,367 | 458 |
| R-squared | 0.294 | 0.306 | 0.335 | 0.249 |
| Number of cid | 127 | 127 | 115 | 115 |

**Main Results**

Replication of Cattaneo and Peri (2016) with Backhaus et al (2015) data

- Table 3

Increase in temp of 1% :

Increases emig rates by almost 2% (4%C&P) in MIC

Decreases emig rates by almost 5% (16% C&P) in LIC

| Dep. Variable: **ln_emig rate** | (1) FE | (2) FE | (3) FE | C&P (2016) FE |
|---|---|---|---|---|
| **Exp. Variables:** | **no_logs** | **logs** | **logs** | **Nologs/logs** |
| wtemp | 0.0548 | | | **0.267*** |
| | [0.0450] | | | [0.155] |
| wtempoor | **-0.198*** | | | **-1.127***** |
| | [0.117] | | | [0.336] |
| wpre | **0.0182**** | | | -0-013 |
| | [0.00890] | | | [0.024] |
| wprepoor | **-0.0301**** | | | -0.159 |
| | [0.0132] | | | [0.116] |
| lnwtem | | 1.706*** | **1.946***** | **3.755**** |
| | | [0.408] | [0.425] | (1.661) |
| lnwtempoor | | -6.540*** | **-6.799***** | **-19.967***** |
| | | [2.459] | [2.468] | (6.607) |
| lnwpre | | 0.0977 | 0.105 | -0.223 |
| | | [0.0946] | [0.108] | (0.325) |
| lnwprepoor | | -0.433** | **-0.440**** | -1.399 |
| | | [0.187] | [0.194] | (1.912) |
| FE (as in Table 2) | | | | |
| Observations | 1,522 | 1,511 | 1,367 | 458 |
| R-squared | 0.340 | 0.315 | 0.334 | 0.05/0.201 |
| Number of cid | 127 | 127 | 115 | 115 |

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

**Main Results**

Replication of Cattaneo and Peri (2016) with Backhaus et al (2015) data

# Table 5

- **Only in the second sample:** A non-linearity in temp also captures the changes in the marginal impact on migration

| | (1) | (2) | (3) |
|---|---|---|---|
| VARIABLES | FE | FE | FE |
| | | MIC | Poor |
| lnwtem | 7.317*** | 7.194*** | -27.45*** |
| | [1.834] | [2.209] | [8.012] |
| lnwtem_squared | -1.380*** | -1.838*** | 3.520** |
| | [0.435] | [0.542] | [1.613] |
| lnwpre | -0.0392 | 0.0800 | -2.225* |
| | [0.122] | [0.136] | [1.152] |
| lnwpre_squared | 0.0287 | 0.0184 | 0.391 |
| | [0.0273] | [0.0324] | [0.273] |
| Country FE | yes | yes | yes |
| Year3-region FE | yes | yes | yes |
| Observations | 1,367 | 1,072 | 384 |
| R-squared | 0.321 | 0.034 | 0.134 |
| Number of cid | 115 | 91 | 32 |

Robust standard errors in brackets

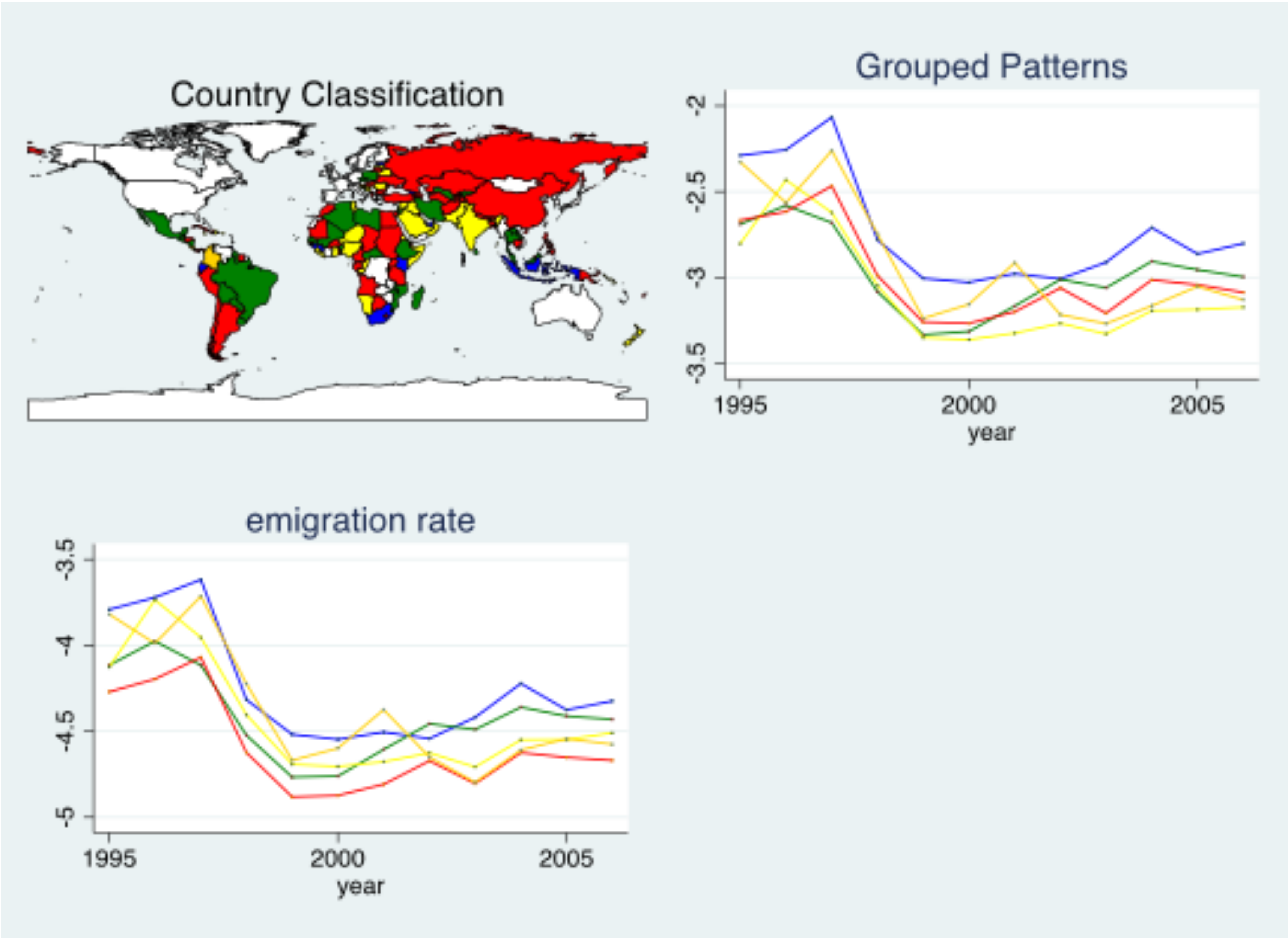
*** p<0.01, ** p<0.05, * p<0.1

# Preliminary Results GFE

- **Only first sample:**
- Model with non-linearities in weighted-temperature and weighted-precipitation

| log_emigration rate | Coef. | Std. Err. |
|---|---|---|
| (G=4) | With group FE | |
| wtemp | -0.1477*** | 0.0135 |
| Wtemp_squared | 0.0035*** | 0.0004 |
| wpre | 0.0558*** | 0.0084 |
| Wpre_squared | -0.0015*** | 0.0002 |
| log_gdpcap | 1.5266*** | 0.2469 |
| log_gdpcap2 | -0.0668*** | 0.0149 |
| _Iassignmen_2 | -1.7371*** | 0.2118 |
| _Iassignmen_3 | -0.7370*** | 0.2299 |
| _Iassignmen_4 | -2.8100*** | 0.2402 |

**Turning points for wtemp=21.61 degrees centigrades**


Country Classification
Grouped Patterns
-2
-2.5
-3
-3.5
1995
2000
2005
year
emigration rate
-3.5
-4
-4.5
-5
1995
2000
2005
year

# Other Results GFE (cont)

| **log_emigration_rate** | **Coef.** | **Std. Err.** | **t** |
|---|---|---|---|
| **wtemp** | **0.224**** | **0.087** | **2.56** |
| wpre | 0.056 | 0.071 | 0.79 |
| log_gdpcap | 1.144*** | 0.224 | 5.1 |
| **wtemp*loggdpcap** | **-0.032***** | **0.010** | **-3.11** |
| wpre*loggdpcap | -0.003 | 0.008 | -0.36 |
| _lassignmen_2 | 0.945 | 0.261 | 3.61 |
| _lassignmen_3 | -0.182 | 0.280 | -0.65 |
| _lassignmen_4 | 1.544 | 0.401 | 3.85 |

- **Only first sample:**
- Model with interaction term between weighted-temperature and log GDP per capita

# Conclusions

- There are incentives but also constrains to migrate
- Increasing temperature in origin increases emigration rates in middle income countries, but decreases emigration rates in low income countries
- Results found using yearly data 1995-2006 in line with results using decade-data 1970-2000
- Lower precipitation increases emigration rate only in LIC the second sample

# Further research

- Examining different groups of countries using bilateral migration data
- Simulations for different countries according to different scenarios (IPCC)
- Optimal number of Groups in GFE when grouping countries endogenously

# Thanks for your attention

# Gravity Model applied to dataset 1

- **Main factors that determine migration:**
- Income origin and destination→+, (-)
- Unemployment rates or and dest→+, (-)
- Travel cost→(-)
- Immigr. policies destination, stability origin
- Cultural similarities: colonial rel, trade, (+)
- Others: Inequality, capital market imperf, demography
- Climatic factors

# Empirical strategy

- GM specification that models time-variant multilateral resistance (dest), as suggested in the trade literature

$$\ln M_{ijt} = \alpha_0 + \alpha_1 \text{lnwtem}_{it} + \alpha_2 \text{lnwpre}_{it} + \alpha_3 \ln \text{GDPH}_{it} + \alpha_5 \text{DemPre}_{it} + \alpha_6\, U_{it} + \alpha_8 \text{TradeGDP}_{it} + \alpha_9 \text{lnDist}_{ij} + \alpha_{10} \text{Contig}_{ij} + \alpha_{11}\, \text{Lang}_{ij} + \alpha_{12}\, \text{SameCont}_{ij} + \alpha_{13} \text{Colony}_{ij} + \alpha_{14} \text{EU}_{ijt} + \varphi_t + \omega_{jt} + \mu_{ijt}$$

# Empirical strategy (cont)

- A second specification adds dynamics as suggested recently (Dunlevy, 1993, Ruyssen et al., 2011)

$$\ln \mathrm{M}_{ijt} = \alpha_0 + \delta_1 M_{ij,t-1} + \delta_2 MS_{ij,t-1} + \alpha_1 \mathrm{lnwtem}_{it} + \alpha_2 \mathrm{lnwpre}_{it} + \alpha_3 \ln \mathrm{GDPH}_{it} +$$
$$\alpha_5 \mathrm{DemPre}_{it} + \alpha_6\, \mathrm{U}_{it} + \alpha_8 \mathrm{TradeGDP}_{it} + \alpha_9 \mathrm{lnDist}_{ij} + \alpha_{10} \mathrm{Contig}_{ij} +$$
$$\alpha_{11}\, \mathrm{Lang}_{ij} + \alpha_{12}\, \mathrm{SameCont}_{ij} + \alpha_{13} \mathrm{Colony}_{ij} + \alpha_{14} \mathrm{EU}_{ijt} + \varphi_t + \omega_{jt} + \mu_{ijt}$$

# Sum Statistics

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **ln_inflows** | 17643 | 4.663284 | 2.518515 | 0 | 12.29601 |
| **ln_stocks** | 12050 | 6.867397 | 3.126274 | 0 | 16.22535 |
| **ln_emig_rate** | 17643 | -4.373365 | 2.300796 | -10.83623 | 3.010124 |
| **ln_wtemperature_origin** | 34694 | 2.841105 | .5282457 | -1.670807 | 3.387202 |
| **ln_wprecipitation_origin** | 35112 | 2.126556 | .8059214 | -2.721096 | 3.702957 |
| **ln_gdp_destination** | 35112 | 10.17991 | .2379786 | 9.457096 | 10.85986 |
| **ln_gdp_origin** | 32205 | 8.061729 | 1.151494 | 4.810944 | 11.08494 |
| **ln_pop_origin** | 35112 | 15.34757 | 2.081953 | 9.754117 | 20.99407 |
| **Demographic pressure** | 33516 | 59.92756 | 6.530337 | 47.72374 | 81.71818 |
| **Unemployment origin** | 15542 | 10.10761 | 6.533774 | .6 | 37.3 |
| **unemployment destination** | 35112 | 6.939474 | 3.316424 | 2 | 22.7 |
| **Trade_to_gdp** | 32642 | 85.44475 | 39.62456 | .3088029 | 275.2324 |
| **ln_distance** | 35112 | 8.710436 | .910424 | 1.334656 | 9.875896 |
| **Contiguity** | 35112 | .0119617 | .1087151 | 0 | 1 |
| **Same_continent** | 35112 | .1555024 | .3623881 | 0 | 1 |
| **Language** | 35112 | .1032126 | .3042407 | 0 | 1 |
| **Colony** | 35112 | .0478469 | .2134452 | 0 | 1 |
| **EU membership** | 35112 | .2611073 | .4392446 | 0 | 1 |

# Main Results
# Static Model

| **Dependent variable:** **Ln_migration_flows** | **LSDV with time and country dummies** | **LSDV with time and pair dummies** | **LSDV with host country-and-time and pair dummies** |
|---|---|---|---|
| **Independent variables:** | **M2** | **M3** | **M4** |
| **Ln_wtemperature_origin** | 0.098 | 0.182 | **0.220*** |
| | (0.208) | (0.147) | (0.132) |
| **Ln_wprecipitation_origin** | -0.061** | -0.047* | **-0.049**** |
| | (0.030) | (0.025) | (0.022) |
| **Ln_GDP_destination** | 1.840*** | 1.555*** | |
| | (0.275) | (0.254) | |
| **Ln_GDP_origin** | 1.453*** | 1.134*** | 1.105*** |
| | (0.518) | (0.439) | (0.402) |
| **ln_GDP_origin_sq** | -0.095*** | -0.082*** | -0.078*** |
| | (0.030) | (0.025) | (0.023) |
| **Demographic_preasure** | -0.002 | 0.015 | 0.020* |
| | (0.014) | (0.012) | (0.011) |
| **Unemployment_destination** | -0.086*** | -0.123*** | |
| | (0.011) | (0.010) | |
| **Trade_to_GDP ratio** | 0.002** | 0.002** | 0.002*** |
| | (0.001) | (0.001) | (0.001) |
| **Ln_distance** | -0.010 | | |
| | (0.034) | | |
| **Contiguity** | -0.191 | | |
| | (0.214) | | |
| **Same_continent** | 1.528*** | | |
| | (0.132) | | |
| **Common language** | 0.982*** | | |
| | (0.124) | | |
| **Colonial relationship** | 2.134*** | | |
| | (0.173) | | |
| **European Union Membership** | 0.051 | 0.096*** | 0.041 |
| | (0.044) | (0.032) | (0.057) |
| **R-squared** | 0.772 | 0.203 | 0.316 |
| **N** | 16109 | 16109 | 16109 |

# Main Results Static Model (Cont)

| **Dependent variable:** **Ln_migration_stock** | **LSDV with time dummies** | **LSDV with time and country dummies** | **LSDV with time and pair dummies** |
|---|---|---|---|
| **Independent variables:** | **M1** | **M2** | **M3** |
| **Ln_wtemperature_origin** | 0.252* | 0.761*** | 0.478*** |
| | (0.143) | (0.268) | (0.180) |
| **Ln_wprecipitation_origin** | -0.166* | -0.035 | -0.037 |
| | (0.090) | (0.037) | (0.023) |
| **R-squared** | 0.826 | 0.397 | 0.478 |
| **N** | 10785 | 10785 | 10785 |

| **dep var:** **ln_migration_rates** | **LSDV with time and country dummies** | **LSDV with time and pair dummies** | **LSDV with host country-and-time and pair dummies** |
|---|---|---|---|
| **Independent variables:** | **M2** | **M3** | **M4** |
| **ln_wtemperature_origin** | 0.147 | 0.227* | 0.265** |
| **se** | (0.210) | (0.148) | (0.134) |
| **ln_wprecipitation_origin** | -0.064** | -0.051** | -0.052** |
| **se** | (0.030) | (0.024) | (0.022) |
| **R-squared** | 0.723 | 0.164 | 0.280 |
| **N** | 16109 | 16109 | 16109 |

# Main Results Dynamic Model

| **dep var: ln_migration_flows** | **LSDV with time and country dummies** | **LSDV with time dummies and bilateral FE** | **Instrumental Variables First Diff.** |
|---|---|---|---|
| **Independent variables:** | **M2** | **M3** | **M4** |
| **ln_stocks (t-1)** | 0.171*** | 0.139*** | 0.039 |
| | (0.013) | (0.034) | (0.079) |
| **ln_inflows (t-1)** | 0.739*** | 0.413*** | -0.161** |
| | (0.015) | (0.022) | (0.070) |
| **ln_wtem_origin** | 0.171 | 0.126 | -0.273 |
| **se** | (0.180) | (0.168) | (0.201) |
| **ln_wpre_origin** | -0.087*** | -0.085*** | -0.067*** |
| **se** | (0.033) | (0.029) | (0.024) |

| **Dep var: ln_emig_rates** | **ols, time dummies** | **time and i,j, fe** | **time and pair fe** |
|---|---|---|---|
| **Indep. Variables:** | b/se | b/se | b/se |
| **L.ln_emig_rate** | 0.927*** | 0.740*** | 0.409*** |
| | (0.006) | (0.015) | (0.023) |
| **L.ln_stocks** | 0.026*** | 0.172*** | 0.147*** |
| | (0.005) | (0.014) | (0.034) |
| **ln_wtem_or** | -0.023* | 0.175 | 0.133 |
| | (0.013) | (0.181) | (0.169) |
| **ln_wpre_or** | -0.007 | -0.090*** | -0.085*** |
| | (0.007) | (0.033) | (0.030) |

# Robustness I: Instrumental Variables

| Dep variables: | Instrumental Variables Ln_emig_rate |
|---|---|
| Indep. Var: | b/se |
| LD.ln_emig_rate | -0.670* |
| | (0.362) |
| LD.ln_stocks | 0.432 |
| | (0.274) |
| LD.ln_wtem_or | -0.112 |
| | (0.181) |
| LD.ln_wpre_or | -0.081*** |
| | (0.029) |

# Robustness II: Heckman

| **Dependent variable:** | **Ln migration inflows** | **Migration inflows** |
|---|---|---|
| **Ln_wtemperature_origin** | 0.313*** | -0.035 |
| se | -0.12 | -0.037 |
| **Ln_wprecipitation_origin** | -0.064** | -0.165*** |
| se | -0.026 | -0.027 |

| | | |
|---|---|---|
| **Stability (used as selection variable in the first step** | Coeff | -0.395*** |
| | se | -0.025 |